

## CLAIMS:

1. A method of sharpness enhancement of an input signal comprising
  - detecting in a first spatial direction a first subset of edges in the input signal to obtain a first detector signal,
  - detecting in the first spatial direction a second subset of edges in the input signal to obtain a second detector signal, said second subset being different from the first subset,
  - determining a peaking factor by using a predetermined two-dimensional enhancement function allocating values for the peaking factor to combinations of values of the first detector signal and the second detector signal, and
  - 10 multiplying the first detector signal with the peaking factor to obtain a peaked signal.
2. A method of sharpness enhancement as claimed in claim 1, wherein
  - the detecting the first subset of edges comprises high-pass filtering the input image signal to obtain a high-pass filtered signal,
  - the detecting the second subset of edges comprises band-pass filtering the input image signal to obtain a band-pass filtered signal,
  - the determining the peaking factor by using a predetermined two-dimensional enhancement function being adapted for allocating values for the peaking factor to combinations of values of the high-pass filtered signal and the band-pass filtered signal, and
  - 20 multiplying the high-pass filtered signal with a multiplying factor based on the peaking factor.
3. A method of sharpness enhancement as claimed in claim 2, wherein
  - the high-pass filtering comprises horizontal high-pass filtering a horizontal component of the input image signal to obtain a horizontal high-pass filtered signal,
  - the band-pass filtering comprises horizontal band-pass filtering the horizontal component of the input image signal to obtain a horizontal band-pass filtered signal, and

the determining of the peaking factor comprises using a predetermined two-dimensional horizontal enhancement function for allocating values for a horizontal peaking factor to combinations of values of the horizontal high-pass filtered signal and the horizontal band-pass filtered signal.

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4. A method of sharpness enhancement as claimed in claim 3, wherein said horizontal enhancement function has a relatively low value if

- (i) a value of the horizontal high-pass filtered signal and a value of the horizontal band-pass filtered signal are substantially equal,
- 10 (ii) the value of the horizontal high-pass filtered signal is larger than a first predetermined value, or
- (iii) the value of the horizontal band-pass filtered signal is larger than a second predetermined value, and

wherein, if (i) is not valid, said horizontal enhancement function has a relatively high value

15 if:

- (iv) the value of the horizontal high-pass filtered signal is smaller than the first predetermined value, or
- (v) the value of the horizontal band-pass filtered signal is smaller than the second predetermined value.

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5. A method of sharpness enhancement as claimed in claim 3, wherein the method further comprises

vertical high-pass filtering a vertical component of the input image signal to obtain a vertical high-pass filtered signal,

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vertical band-pass filtering the vertical component of the input image signal to obtain a vertical band-pass filtered signal,

the determining of the peaking factor comprises using a predetermined two-dimensional vertical enhancement function for allocating values for a vertical peaking factor to combinations of values of the vertical high-pass filtered signal and the vertical band-pass filtered signal.

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6. A method of sharpness enhancement as claimed in claim 5, wherein said vertical enhancement function has a relatively low value if

(i) a value of the vertical high-pass filtered signal and a value of the vertical band-pass filtered signal are substantially equal,

(ii) the value of the vertical high-pass filtered signal is relatively large, or

(iii) the value of the vertical band-pass filtered signal is relatively large, and

5 wherein said vertical enhancement function has a relatively high value if

(iv) the value of the vertical high-pass filtered signal is relatively small and (i) is not valid, or

(v) the value of the vertical band-pass filtered signal is relatively small and (i) is not valid.

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7. A method of sharpness enhancement as claimed in claim 5, wherein the multiplying comprises

multiplying the horizontal high pass filtered signal with the horizontal peaking factor to obtain a horizontal correction factor,

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multiplying the vertical high pass filtered signal with the vertical peaking factor to obtain a vertical correction factor,

summing the horizontal correction factor and the vertical correction factor to obtain a total correction factor, and

summing the total correction factor to the input image signal.

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8. A method of sharpness enhancement as claimed in claim 7, wherein the summing of the horizontal correction factor and the vertical correction factor comprises weighting the horizontal correction factor with a horizontal weighting factor, and the vertical correction factor with a vertical weighting factor, wherein the horizontal weighting factor has 25 a lower value when the vertical correction factor surpasses a first threshold, and wherein the vertical weighting factor has a lower value when the horizontal correction factor surpasses a second threshold.

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9. A method of sharpness enhancement as claimed in claim 7, wherein the method further comprises determining a level of noise being present in the input image signal, and modifying the horizontal peaking factor and/or vertical peaking factor in dependence on the level of noise in order to reduce an enhancement of noise.

10. A method of sharpness enhancement as claimed in claim 9, wherein the determining of the level of noise comprises estimating a standard deviation of the noise.

11. A method of sharpness enhancement as claimed in claim 3, wherein the input 5 image signal represents an image formed by a matrix of pixels, a position of a pixel in the matrix being defined by indices m,n wherein the index n indicates a horizontal position and the index m indicates a vertical position, and wherein the horizontal high-pass filtering comprises Laplacian filtering defined by  $Zx(m,n)=2L(m,n)-L(m,n-1)-L(m,n+1)$ , and wherein the horizontal band-pass filtering comprises filtering defined by  $Dx(m,n)=L(m,n+1)-L(m,n-1)$ , and wherein L(m,n) is related to the luminance of a pixel at position m,n, L(m,n-1) is 10 related to the luminance of a pixel at position m,n-1, and L(m,n+1) is related to the luminance of a pixel at position m,n+1.

12. A method of sharpness enhancement as claimed in claim 5, wherein the input 15 image signal represents an image being formed by a matrix of pixels, a position of a pixel in the matrix being defined by indices m,n wherein the index n indicates a horizontal position and the index m indicates a vertical position, and wherein the vertical high-pass filter comprises a Laplacian filter defined by  $Zy(m,n)=2L(m,n)-L(m-1,n)-L(m+1,n)$ , wherein the vertical band-pass filter is a filter  $Dy(m,n)=L(m+1,n)-L(m-1,n)$ , and wherein L(m,n) is 20 related to the luminance of a pixel at position m,n, L(m-1,n) is related to the luminance of a pixel at position m-1,n, and L(m+1,n) is related to the luminance of a pixel at position m+1,n.

13. A method of sharpness enhancement as claimed in claim 10, wherein the estimating of the standard deviation comprises determining for each pixel for a 3 by 3 pixels 25 window:

$$ro(m,n)=1/8 \sum_{i=-1}^1 \sum_{j=-1}^1 |L(m+i,n+j)-vgl(m,n)|$$

wherein vgl(m,n) is an approximation of an average value of the luminance values of the 30 pixels in the 3 by 3 pixels window.

14. A method of sharpness enhancement as claimed in claim 13, wherein the average value is determined by  $vgl(m,n)=L(m,n)**W1$ , wherein \*\* denotes a convolution,

and W1 is a convolution mask indicating a weighting factor for each of the pixels in the 3 by 3 pixel window.

15. A method of sharpness enhancement as claimed in claim 14, wherein for each  
5 pixel a histogram is calculated with the following expression:

$$h(k) = \begin{cases} |\{(m,n) \mid k-1/2 \leq ro(m,n) < k+1/2\}| & \text{if } k=1, 2, \dots, k_{\max}, \text{ or} \\ 2 |\{(m,n) \mid 0 \leq ro(m,n) < 1/2\}| & \text{if } k=0, \end{cases}$$

wherein  $|\{\dots\}|$  denotes the number of elements of the set  $\{\dots\}$ ,

and wherein an estimated value for a standard deviation of the noise level is the value  $k=M$   
10 corresponding to the highest value in the histogram, and wherein the horizontal peaking  
factor and the vertical peaking factor depend on said estimated value.

16. A method of sharpness enhancement as claimed in claim 1, wherein  
the detecting the first subset of edges comprises high-pass filtering the input  
15 image signal to obtain a first high-pass filtered signal,  
the detecting the second subset of edges comprises high-pass filtering the input  
image signal to obtain a second high-pass filtered signal,  
the determining the peaking factor by using a predetermined two-dimensional  
enhancement function being adapted for allocating values for the peaking factor to  
20 combinations of values of the first high-pass filtered signal and the second high-pass filtered  
signal, and  
multiplying the first high-pass filtered signal with the peaking factor.

17. A method of sharpness enhancement as claimed in claim 16, wherein  
the first high-pass filtering comprises horizontal high-pass filtering a  
horizontal component of the input image signal to obtain a first horizontal high-pass filtered  
25 signal,  
the second high-pass filtering comprises horizontal high-pass filtering the  
horizontal component of the input image signal to obtain a second horizontal band-pass  
30 filtered signal, and  
the determining of the peaking factor comprises using a predetermined two-  
dimensional horizontal enhancement function for allocating values for a horizontal peaking  
factor to combinations of values of the first horizontal high-pass filtered signal and the  
second horizontal high-pass filtered signal.

18. A method of sharpness enhancement as claimed in claim 17, wherein the method further comprises

first vertical high-pass filtering a vertical component of the input image signal

5 to obtain a first vertical high-pass filtered signal,

second vertical high-pass filtering the vertical component of the input image signal to obtain a second vertical band-pass filtered signal,

the determining of the peaking factor comprises using a predetermined two-dimensional vertical enhancement function for allocating values for a vertical peaking factor  
10 to combinations of values of the first vertical high-pass filtered signal and the second vertical high-pass filtered signal.

19. A sharpness enhancement circuit comprising

a first edge detector for detecting in a first spatial direction a first subset of  
15 edges in the input signal to obtain a first detector signal,  
a second edge detector for detecting in the first spatial direction a second subset of edges in the input signal to obtain a second detector signal, said second subset being different from the first subset,

20 a means for determining a peaking factor by using a predetermined two-dimensional enhancement function allocating values for the peaking factor to combinations of values of the first detector signal and the second detector signal, and

a multiplier for multiplying the first detector signal with the peaking factor to obtain a peaked input signal.

25 20. A display apparatus comprising a matrix display and a sharpness enhancement circuit as claimed in claim 19.